

Offset Waveguide Transmission Measurements

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Abstract

Transmission loss measurements in S-band waveguide due to waveguide section misalignment have been performed in the Electromagnetic Properties Measurement Laboratory in NASA Langley's Electromagnetics Research Branch. These measurements were performed in support of the Hydrostar program, to determine the feasibility of using deployable waveguide sections in a large space radiometer. Low losses are essential for radiometer applications; these measurements were conducted in order to determine what misalignment tolerances were acceptable for such a deployable structure.

Introduction

This report describes measurements to determine transmission losses in S-band (2.60 - 3.95 GHz) waveguide sections due to misalignment of the sections relative to each other. The experiments were performed in support of the Hydrostar program, to determine the feasibility of using deployable waveguide sections in a large space radiometer. The waveguide sections would possibly be hinged and folded for launch, then deployed in space to form long sections of waveguide [ref. 1]. Since very low losses are required for radiometer applications, the effects of potential misalignment after deployment of the waveguide sections may be significant. These measurements were performed in the Electromagnetic Properties Measurement Laboratory [ref. 2] in the Electromagnetics Research Branch.

Measurement Setup

The measurement setup consists of a waveguide offset fixture (described below) connected to the two ports of a Hewlett-Packard 8510C network analyzer by coaxial cables and coax-to-waveguide transitions (see fig. 1). The waveguide offset fixture is a stand which clamps two pieces of S-band waveguide, each 8.0 inches long. One piece of waveguide is held fixed, while the position of the other piece of waveguide can be adjusted in three directions independently using micrometer adjustments (see fig. 2). The maximum offset in each direction is 0.5 inches. The measurement setup is shown photographically in Figures 3 and 4.

Procedure

Before the measurements were done, a full two-port calibration was done to the reference planes shown in Figure 1 using a standard S-band waveguide calibration kit. The waveguide offset fixture was then inserted between the coax-to-waveguide adapters between the calibration planes. The waveguide sections were set to the zero offset (aligned) positions and transmission measurements were made in several configurations. The aligned measurement configurations were: waveguide flanges bolted together; waveguide flanges loosely bolted together (bolts in place but not

tightened); waveguide flanges not bolted but clamped together with C-clamps at top and bottom of flanges; and, waveguide flanges not bolted or clamped. The moveable waveguide section was then displaced relative to the fixed section along one axis at a time in increments of 0.025", with S-parameter data (reflection and transmission coefficients) being recorded at each increment (see fig. 2 for a definition of the axes). For the x- and y-offset data, two data files were recorded for each position: one in which the flanges were clamped together at top and bottom using C-clamps, and another in which the flanges were held together only by the spring tension in the fixture. Results were also recorded for cases in which the x- and y-axes were offset equal amounts for zero z-offset, and also for cases in which the x-, y-, and z-axes were all offset equal amounts.

Results

The amount of data which was taken in this study precludes plotting all the data in this report, so a representative sample has been chosen. The first plot (fig. 5) shows the transmission coefficient (S_{21}) for various aligned cases. This plot is included in order to demonstrate the transmission loss which occurs when the flanges of the waveguide sections are not bolted tightly together, even though they are aligned. The transmission coefficients given in this plot have been normalized to the transmission coefficient for the tightly bolted case in order to remove any effects from the connections between the coax-to-waveguide adapters and the waveguide sections (at the reference planes). It can be noted from this plot that the case in which the flanges were clamped together instead of tightly bolted resulted in only a small reduction in the transmission through the waveguide sections. This clamped, aligned case is used as the reference case for all the other plots shown here. The x- and y-offset cases which are shown are the measurements which were performed with the flanges clamped together. This is in order to eliminate leakage which could occur if the flanges are not tightly in contact with each other, so that the reductions in transmission should be due only to the misalignment. Obviously, for the waveguide sections offset in the z-direction relative to each other, the flanges could not be clamped together.

Figures 6 and 7 show the normalized transmission coefficients for the cases when the waveguide sections are misaligned in the x- and y-directions, respectively. Figure 8 shows the normalized transmission coefficients for simultaneous, equal offsets in the x- and y-directions. Figure 9 gives results for offsets in the z-directions. Figure 10 gives results for simultaneous, equal offsets in x-, y-, and z-directions. For each of these cases, two plots are shown: the first is a plot including a larger range in the offset to show the overall trend of the reduction in transmission due to the offset; the second is a plot showing the first few offset cases on an expanded scale for more detail.

Conclusions

This study has demonstrated the measured reduction in transmission through waveguide sections which are misaligned in various directions. For x-offsets alone, the transmission reductions are seen to be less than 0.05 dB for offsets up to 0.25 inches. For y-offsets alone, transmission reductions of up to about 0.1 dB are observed for offsets up to 0.25 inches. For both x- and y-offsets, the transmission reductions are seen to be less than 0.05 dB for offsets up to 0.25 inches, and in fact for some frequencies a tuning effect seems to be occurring, as the normalized transmission coefficient is greater than 0 dB. For the cases which involve z-offsets, quite large transmission losses are observed, especially over a narrow frequency range whose center frequency decreases as the gap in the z-direction is increased.

References

- [1]. Schroeder, Bailey, Harrington, Kendall, and Campbell, "Design Studies of Large Aperture, High-Resolution Earth Science Microwave Radiometers Compatible With Small Launch Vehicles", NASA Technical Paper 3469, September 1994.
- [2]. Cravey, Tiemsin, Bussell, Dudley, "Dielectric Property Measurements in the Electromagnetic Properties Measurement Laboratory", NASA Technical Memorandum #110147, April 1995.

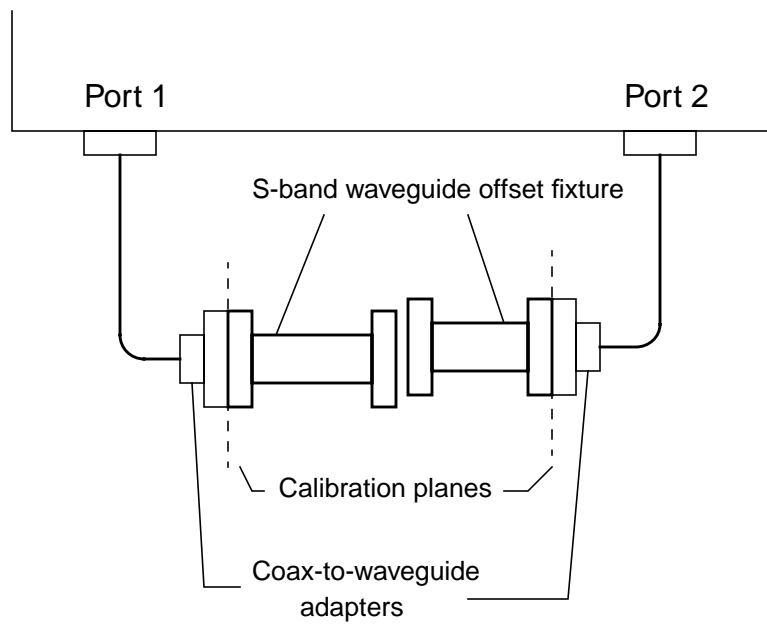


Figure 1. Offset waveguide setup

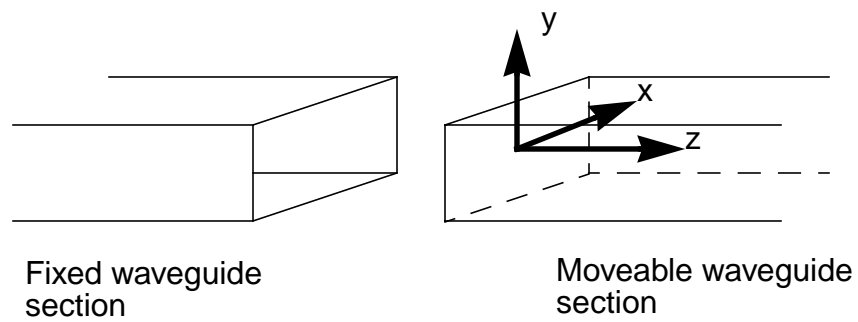


Figure 2. Definition of coordinate system

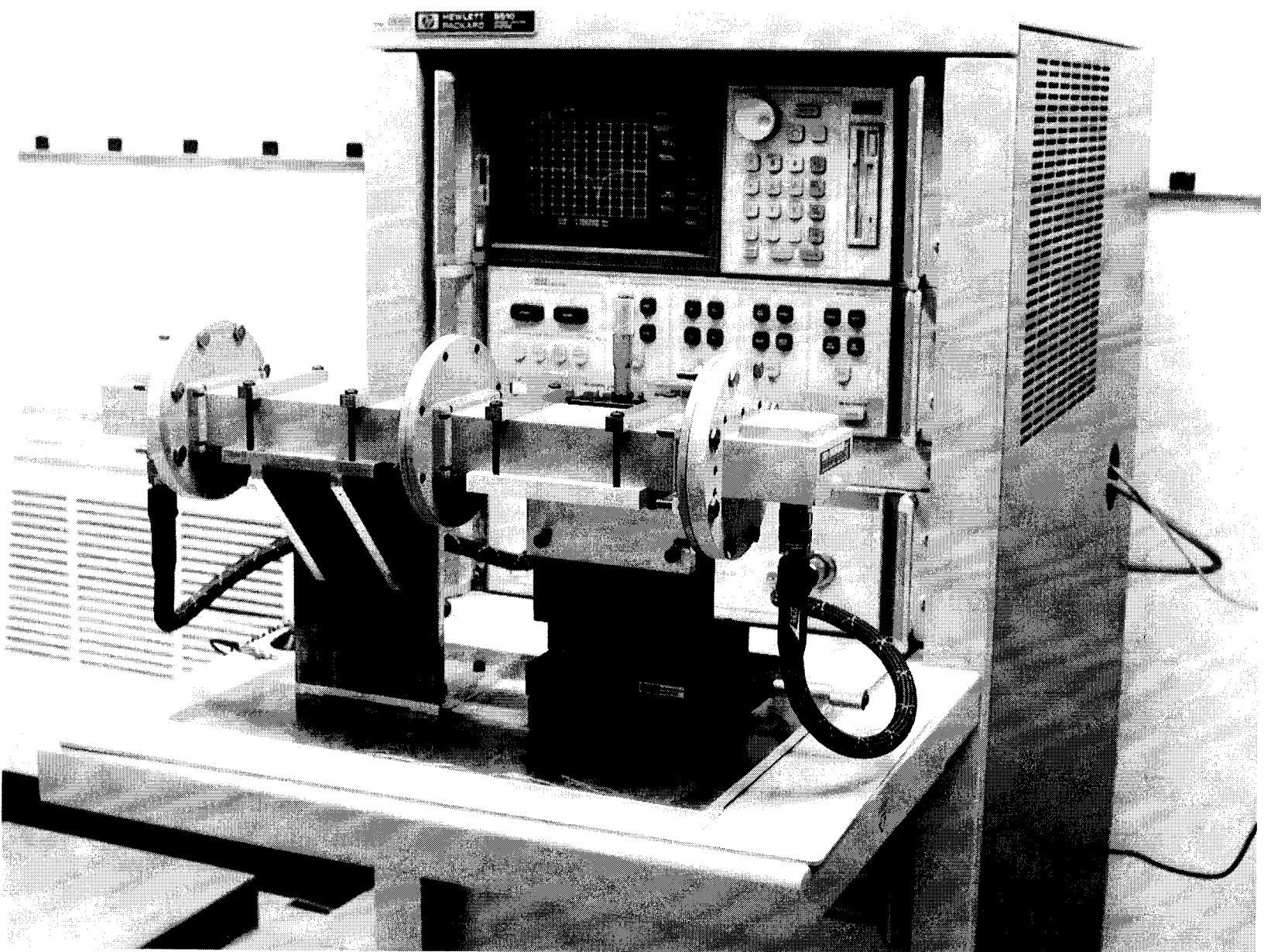


Figure 3. Offset waveguide measurement setup

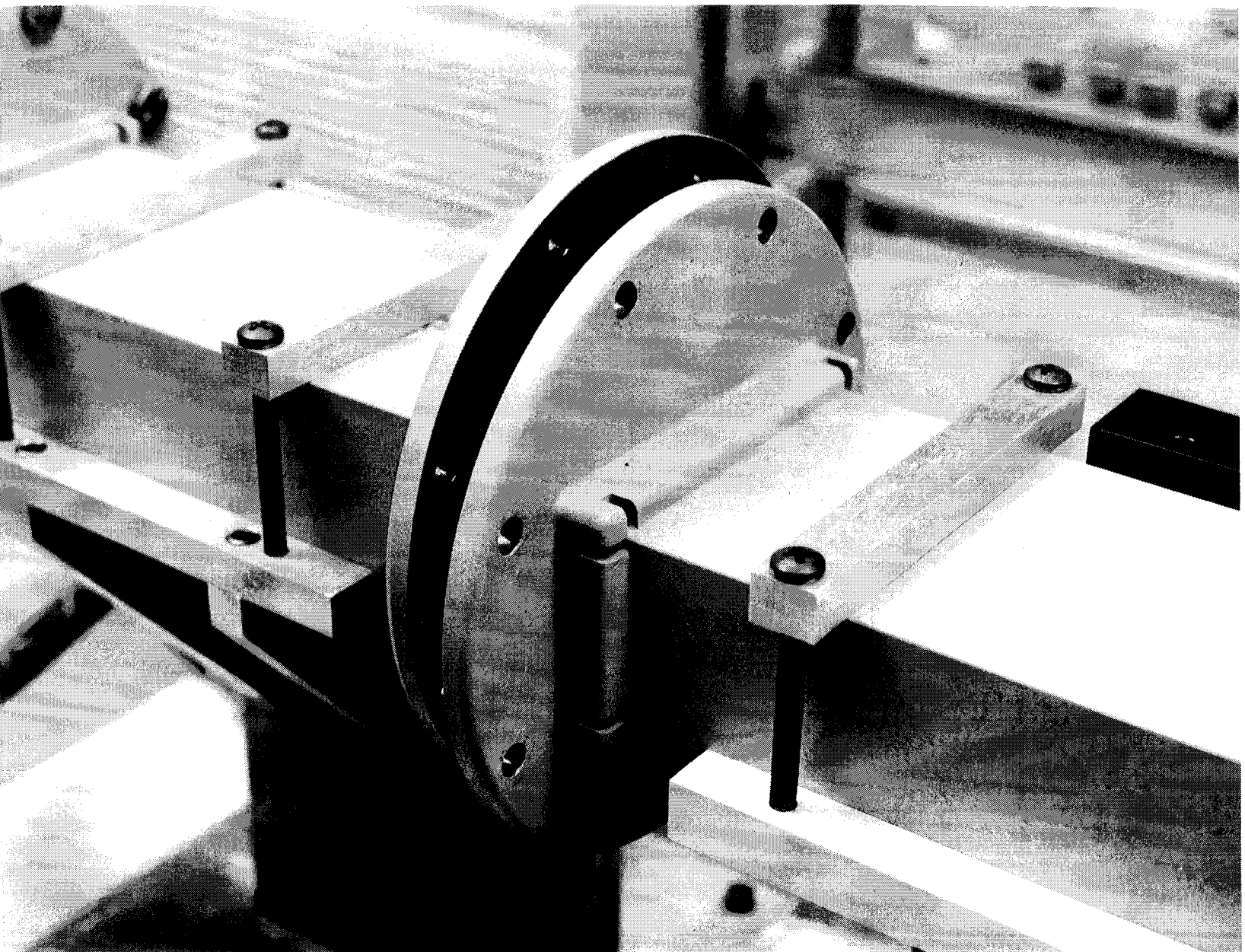


Figure 4. Offset waveguide measurement setup - closeup

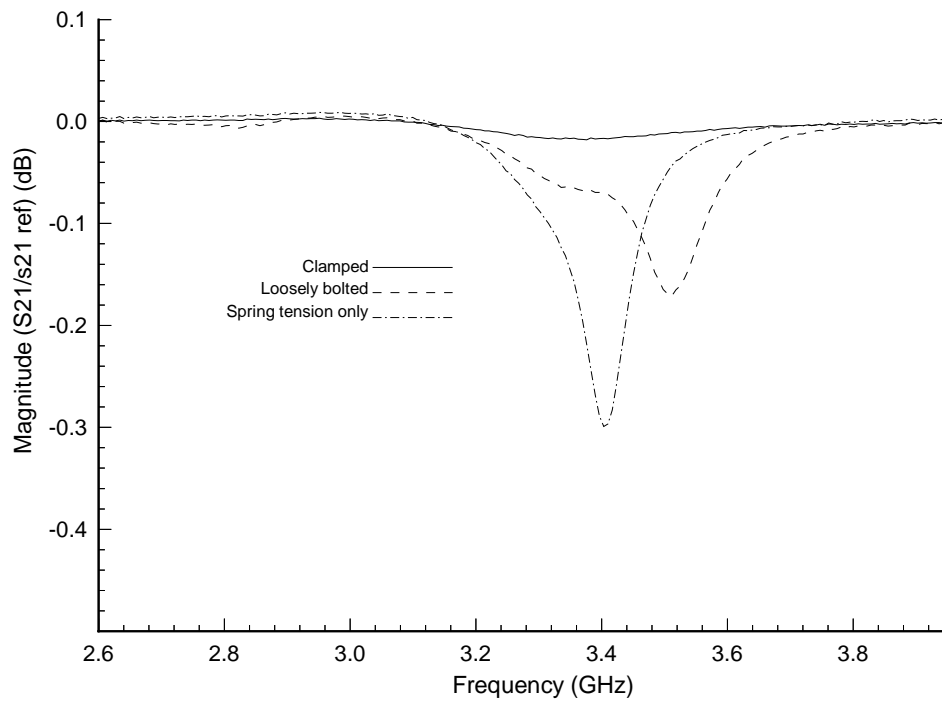


Figure 5. Aligned case

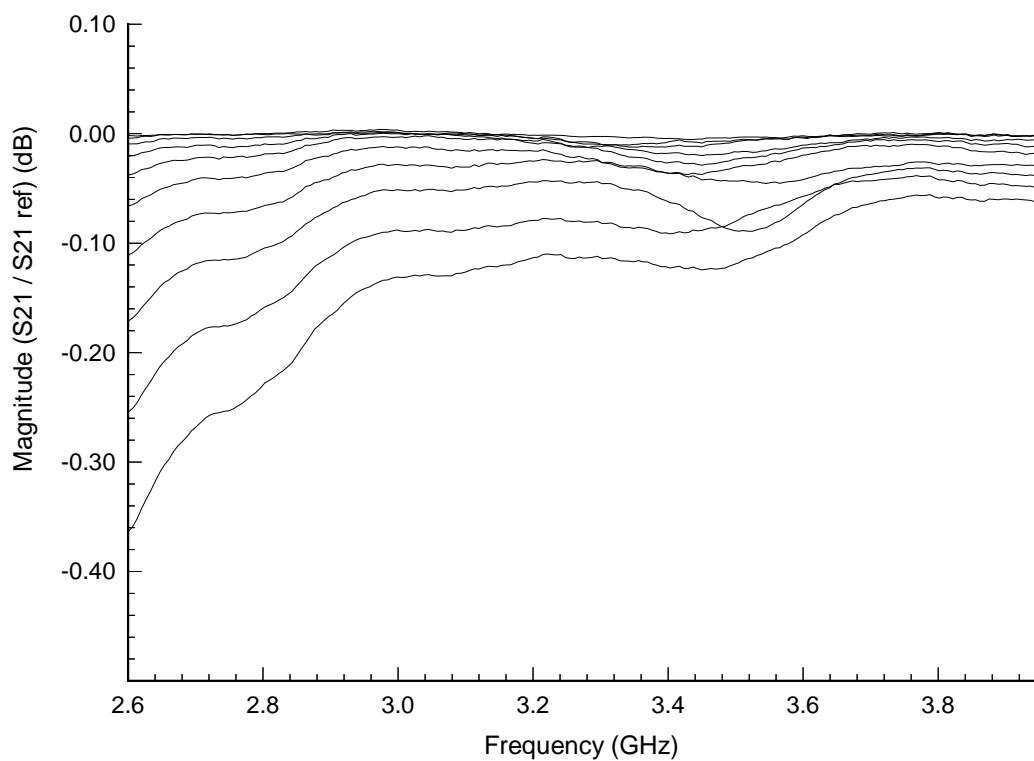


Figure 6(a). x-offset cases, .05" to .5", every .05"

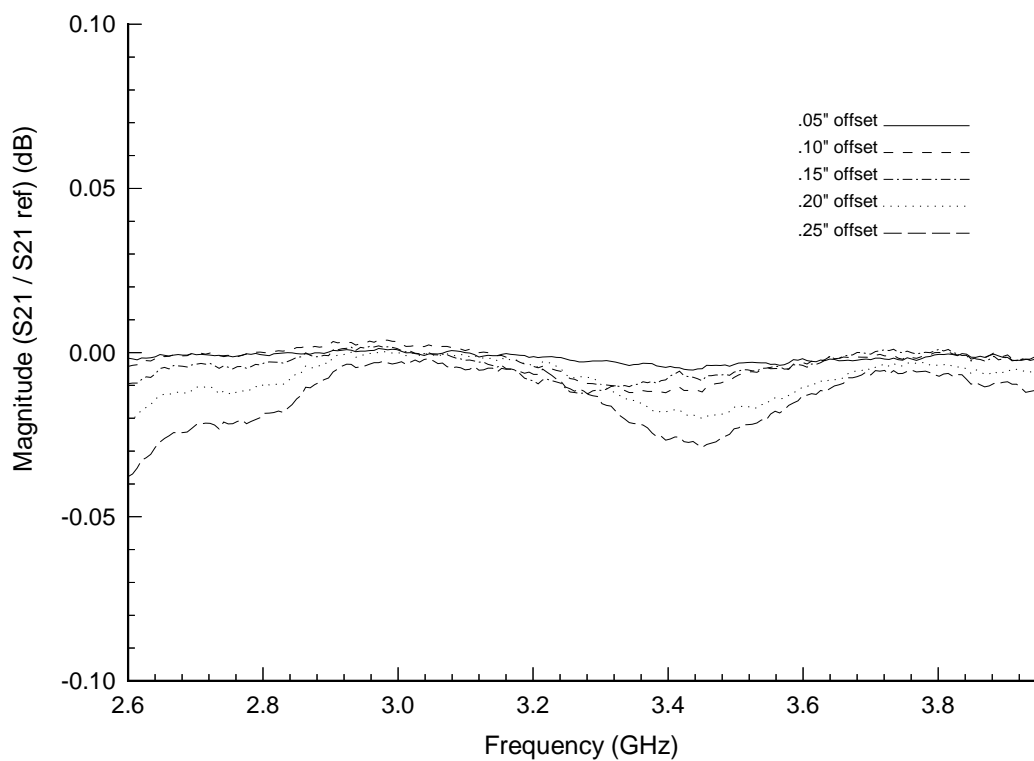


Figure 6(b). x-offset cases, .05 to .25", every .05"

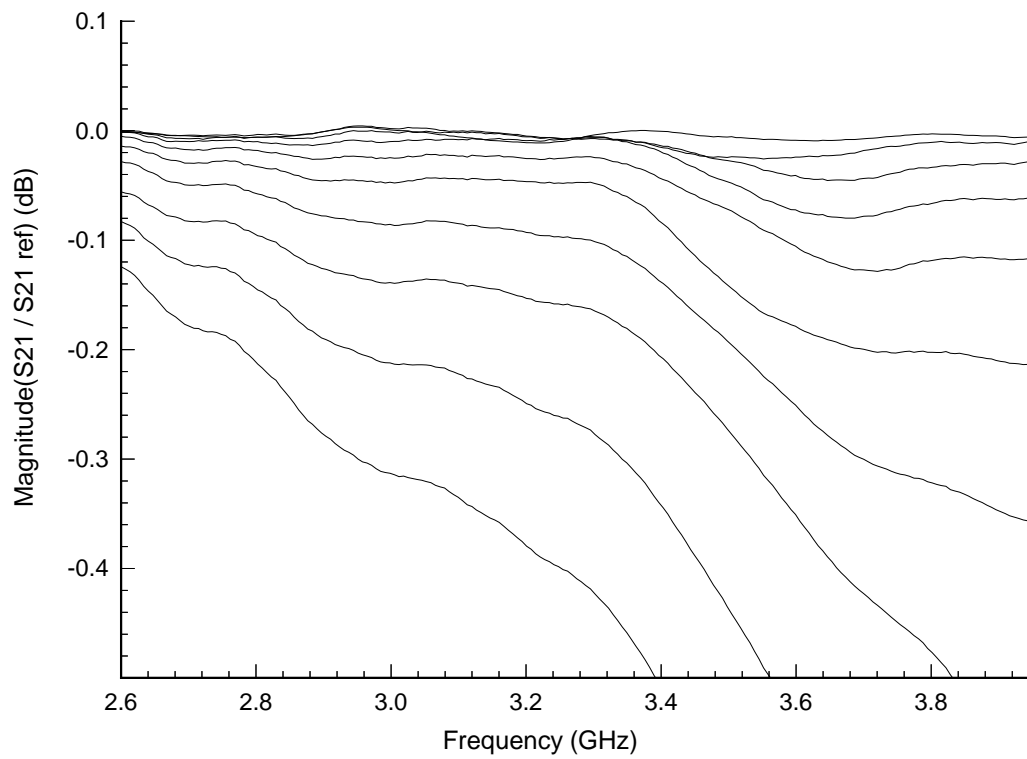


Figure 7(a). y-offset cases, .05" to .5" offsets, every .05"

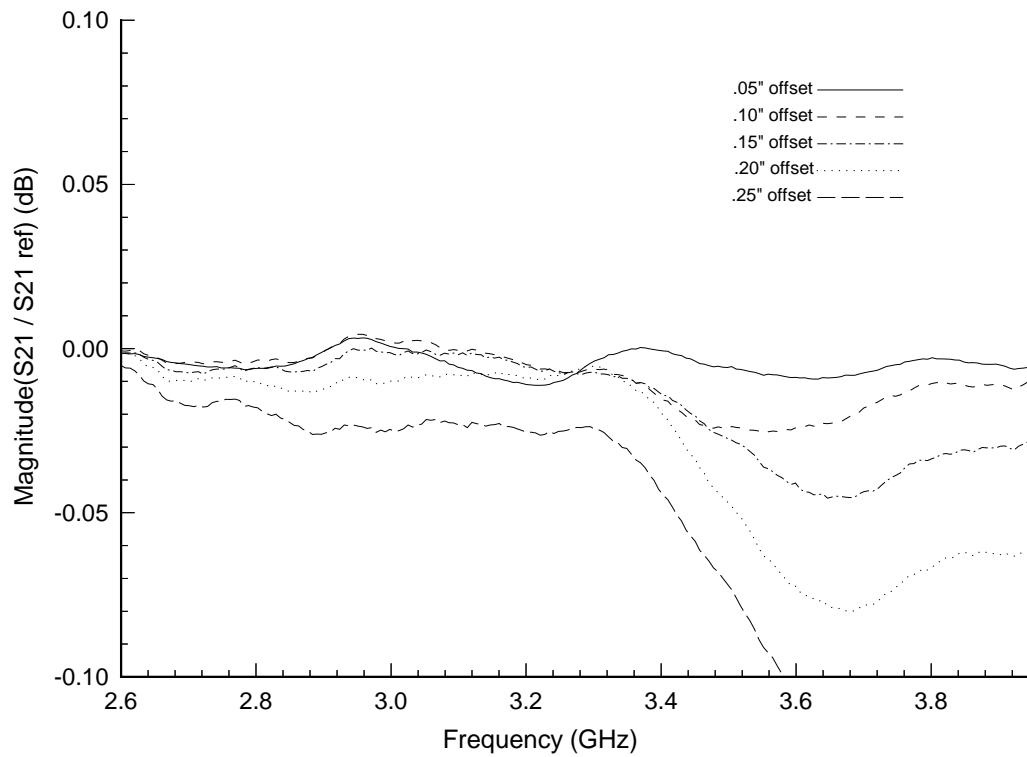


Figure 7(b). y-offset cases, .05" to .025", every .05"

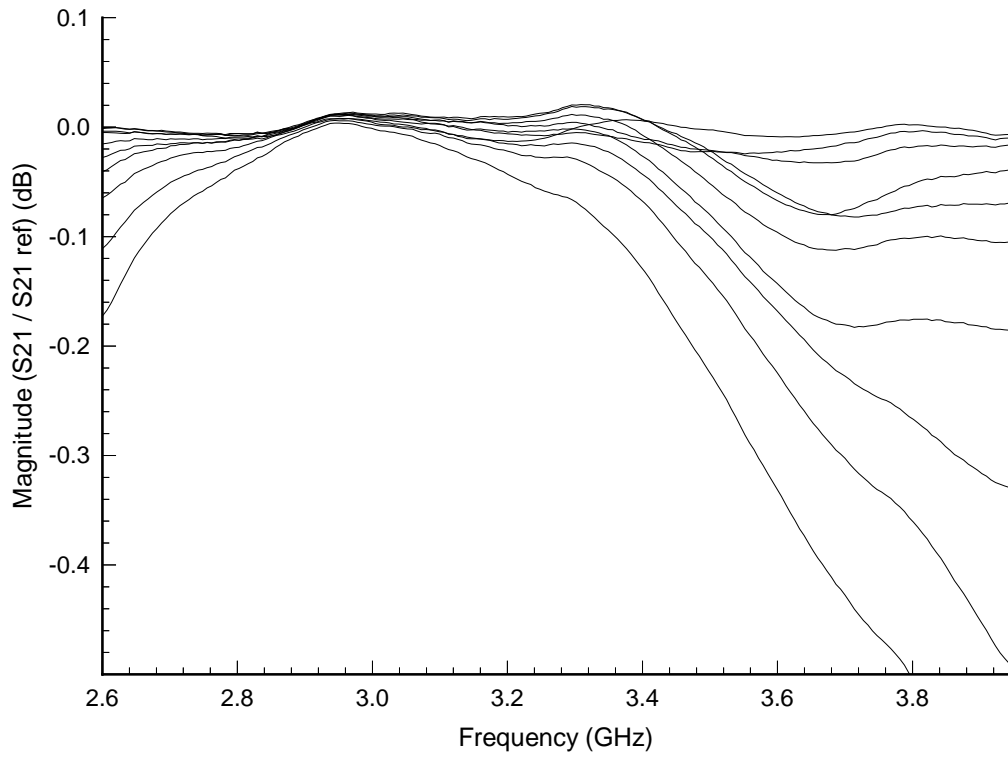


Figure 8(a). x- and y-offset cases, offsets from .05" to .5", every .05"

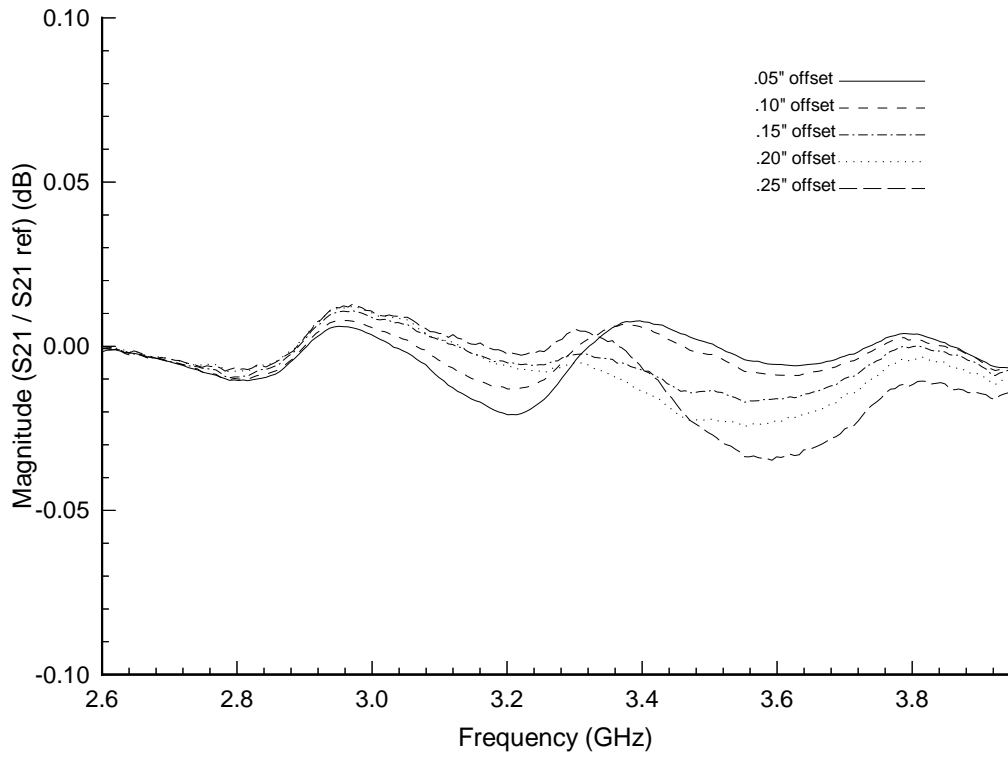


Figure 8(b). x- and y-offset cases, offsets from .05" to .25", every .05"

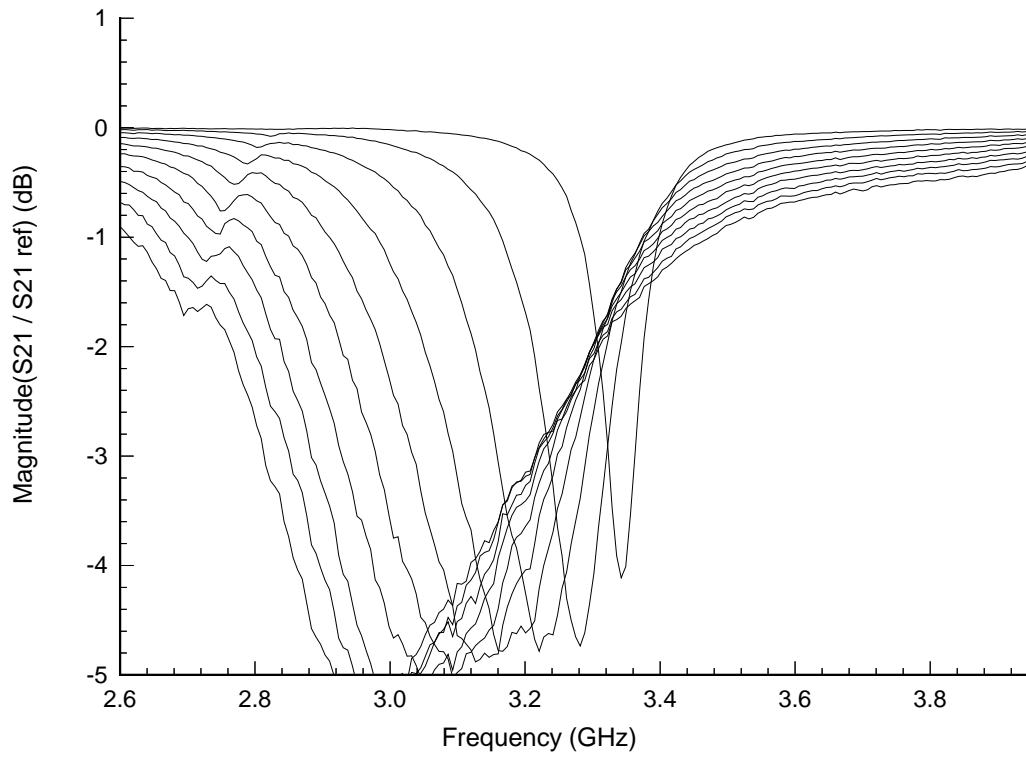


Figure 9(a). z-offset cases, .05" to .25" offsets, every .025"

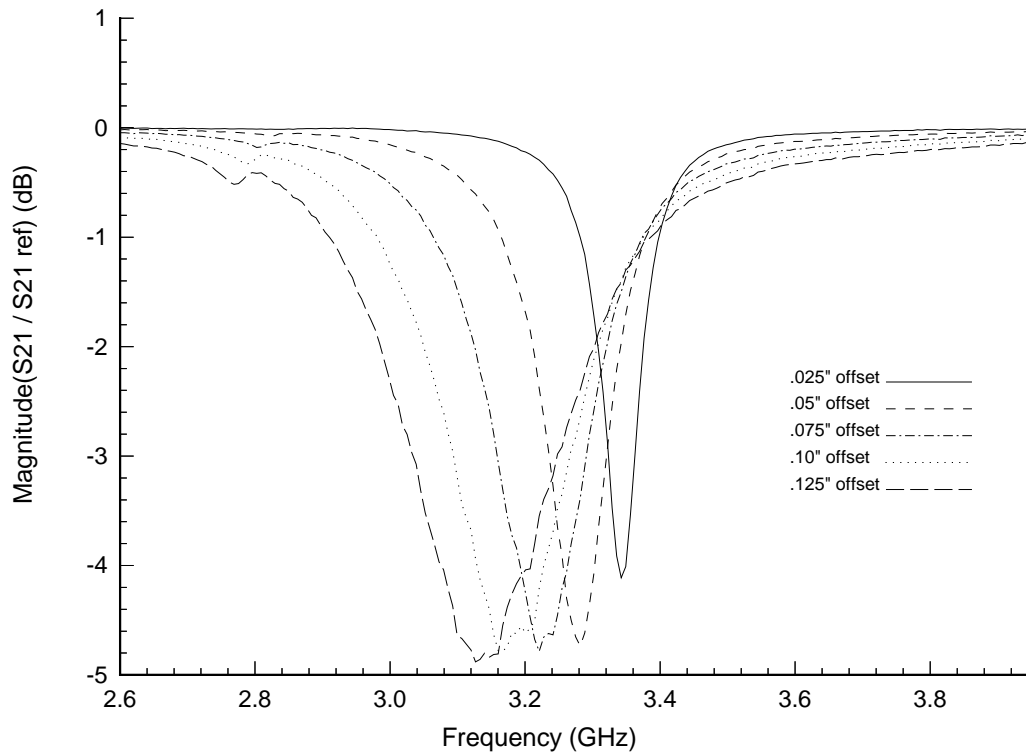


Figure 9(b). z-offset cases, .05" to .125" offsets, every .025"

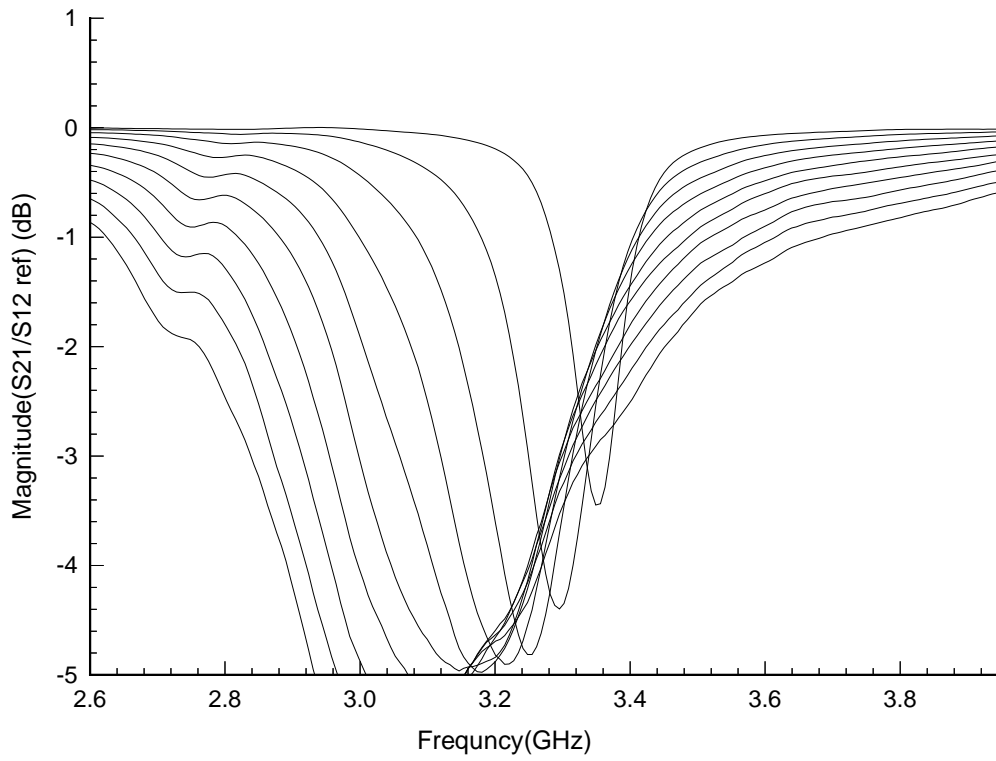


Figure 10(a). x-, y-, and z-offset cases, offsets from .05" to .25", every .025"

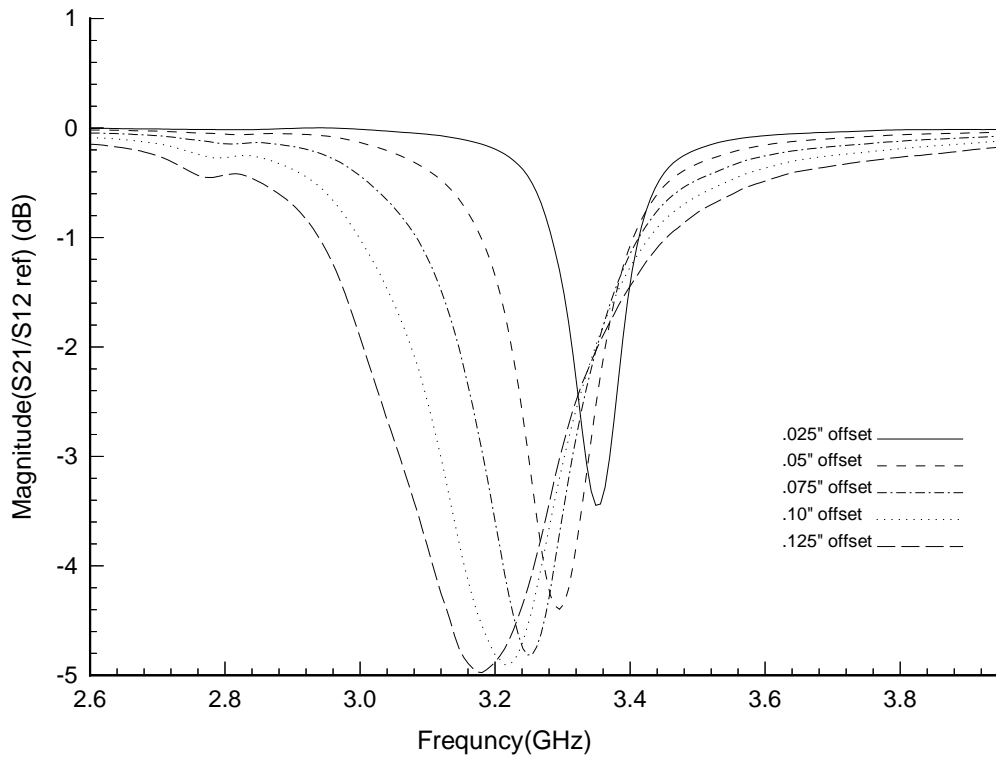


Figure 10(b). x-, y-, and z-offset cases, offsets from .05" to .125", every .025"